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Metallic and Metalloceramic Coating by Thermal Decomposition

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METALLIC AND METALLOCERAMIC COATING BY THERMAL DECOMPOSITION

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ABSTRACT

Metallic and metalloceramic coatings have been prepared by thermal decomposition of a number of inorganic and metallo-organic compounds. The compounds have been applied by spraying and by immersion, especially on ceramic fibers and fiber forms, which are easily coated by this procedure. Penetration of low-density ceramics is examined, and procedures are described that were used for converting the deposited materials to metals, oxides, or metal oxide films. Multiple-component films have also been prepared. Photomicrographs illustrate the structure of these films.

1. INTRODUCTION

Metallic and metalloceramic coatings have a long history of being applied to substantive ceramics either for decorative use or for functional use such as seals or electronic circuitry. These techniques have been adapted for application of metallic coatings to porous bulk ceramics for use as catalysts. The recent availability of high-density, microsized ceramics in the form of fibers has shown the need for methods of applying either metallic or metalloceramic coatings to fibers to modify the fiber properties or to aid in assembling the fibers into structures. Plasma arc coating, while used on substantive ceramics, is too massive for application to fibers. Evaporation or sputtering are insufficiently fast for application to large quantities of individual fibers, and both methods are inapplicable to assembled bunches of fibers. Electroless methods either with or without subsequent electroplating are applicable to masses of individual fibers but are also inapplicable to

bunched fibers because of a lack of uniform penetration into the interstitial pores of the bunched fibers.

In this work a procedure of wide latitude has been developed for coating bunched ceramic fibers with metal or metalloceramic coatings. The procedure is described, examples of the coated fibers are shown, and some of the properties and intended structures are described. Limitations of the procedure are noted.

2. MATERIALS AND PROCEDURE

Ceramic fibers were coated with metals and with metalloceramics by repeated immersion in a solution of the metal or a combination of the metal solution and 5 percent ceramic. The fibers were dried or decomposed to the metal after each immersion. All of the coatings reported here were decomposed at 540 °C (1000 °F). The nickel coatings were reduced from nickel oxide in hydrogen at 760 °C (1400 °F). The nickel oxide was produced by decomposition of nickel nitrate. The platinum coating was produced by decomposition of platinum nitrate. The ceramic fibers were DuPont FP alumina. The metal plasma sprayed to check anchoring was Ni-18Cr-12Al-0.3Y.

3. RESULTS AND DISCUSSION

The objective of coating the ceramic fibers with metal was to develop a method of coupling the fibers to metal structures so that the ends of the fibers were anchored but the remaining portions of the fibers were free. The fibers could have any orientation with respect to the surface of the metal structure. The metal coating on the fiber would act as a strengthening support and an anchor for attachment of the fiber to the metal structure by brazing.

For anchoring the fibers by brazing, the metal coating must be sufficiently thick to avoid immediate solution in the braze. Figure 1 shows 23-μm (0.9-mil) Al_2O_3 fibers that have been coated with 2 μm (0.08 mil) of nickel. The nickel wet the Al_2O_3 so weakly that the nickel beaded. To form

a continuous nickel coat on the ceramic that would act as a strengthening point for anchoring the fiber, 0.3 μm (0.012 mil) of Al_2O_3 was incorporated into the nickel to promote wetting of the Al_2O_3 fiber by the nickel. The results are shown in Fig. 2. The coating was thick enough to allow bonding by careful brazing and continuous enough (circumferential and axial) to support the fiber.

Alternatively, the ceramic fibers may be only thinly coated with metal if the anchoring is performed so rapidly that the anchor is frozen before the metal can dissolve the coating. Some examples are plasma spraying, lasers, electron beam, and rapid quenching. Figure 3 shows Al_2O_3 fibers that have been coated with a thin coat of platinum and then plasma sprayed with NiCrAlY as an anchor. The plasma-sprayed metal bonds tightly to the Al_2O_3 fibers through transition of their platinum coating.

Further studies of morphology, effects of reduction, fiber preparation, and adhesion and comparisons between platinum and nickel coatings are required.

4. SUMMARY

Adding Al_2O_3 to nickel that is then coated on Al_2O_3 fibers provides continuity of the nickel coating so that the coating can be used as an anchor for brazing the fibers to the substrate. Very thin metal coatings on Al_2O_3 fibers can be used for anchoring the fibers if the fibers are plasma sprayed so that the anchor is quenched before it can dissolve the metal coating.

REFERENCE

[1]R.C. Hendricks and G. McDonald, Ceram. Eng. Sci. Proc. 3, 744 (1982).

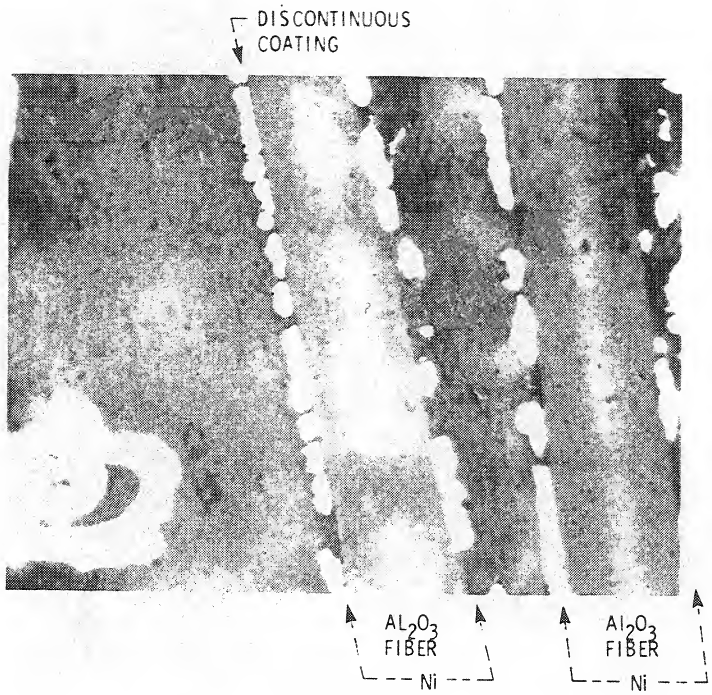

Figure 1. - Al_2O_3 fiber coated with nickel (X1000).

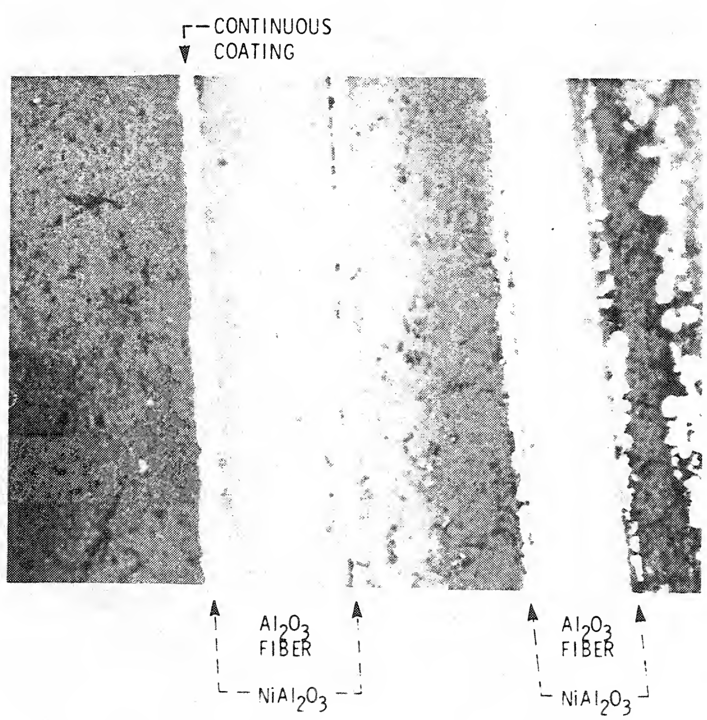

Figure 2. - Al_2O_3 fiber coated with 95 $NiAl_2O_3$ (X1000).

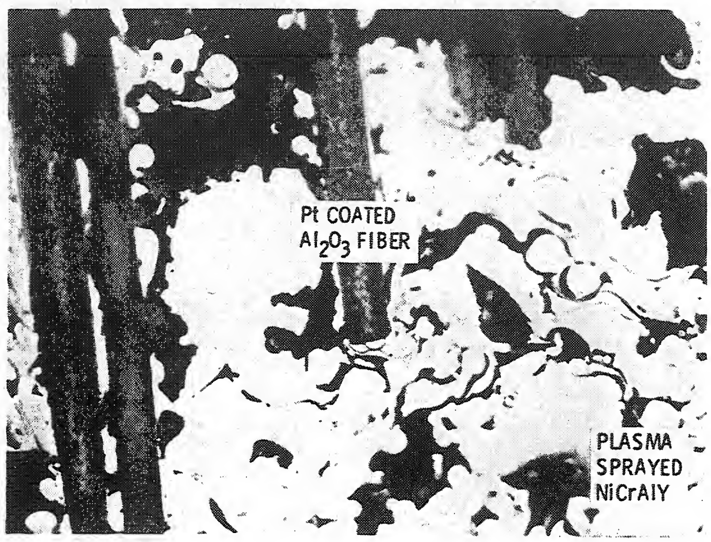

Figure 3. - Al_2O_3 fiber coated with platimum and anchored with plasma-sprayed NiCrAlY (X400).

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